MM5 Modeling for 2005 in the Upper Midwest

prepared for:
Ad-Hoc Met. Group

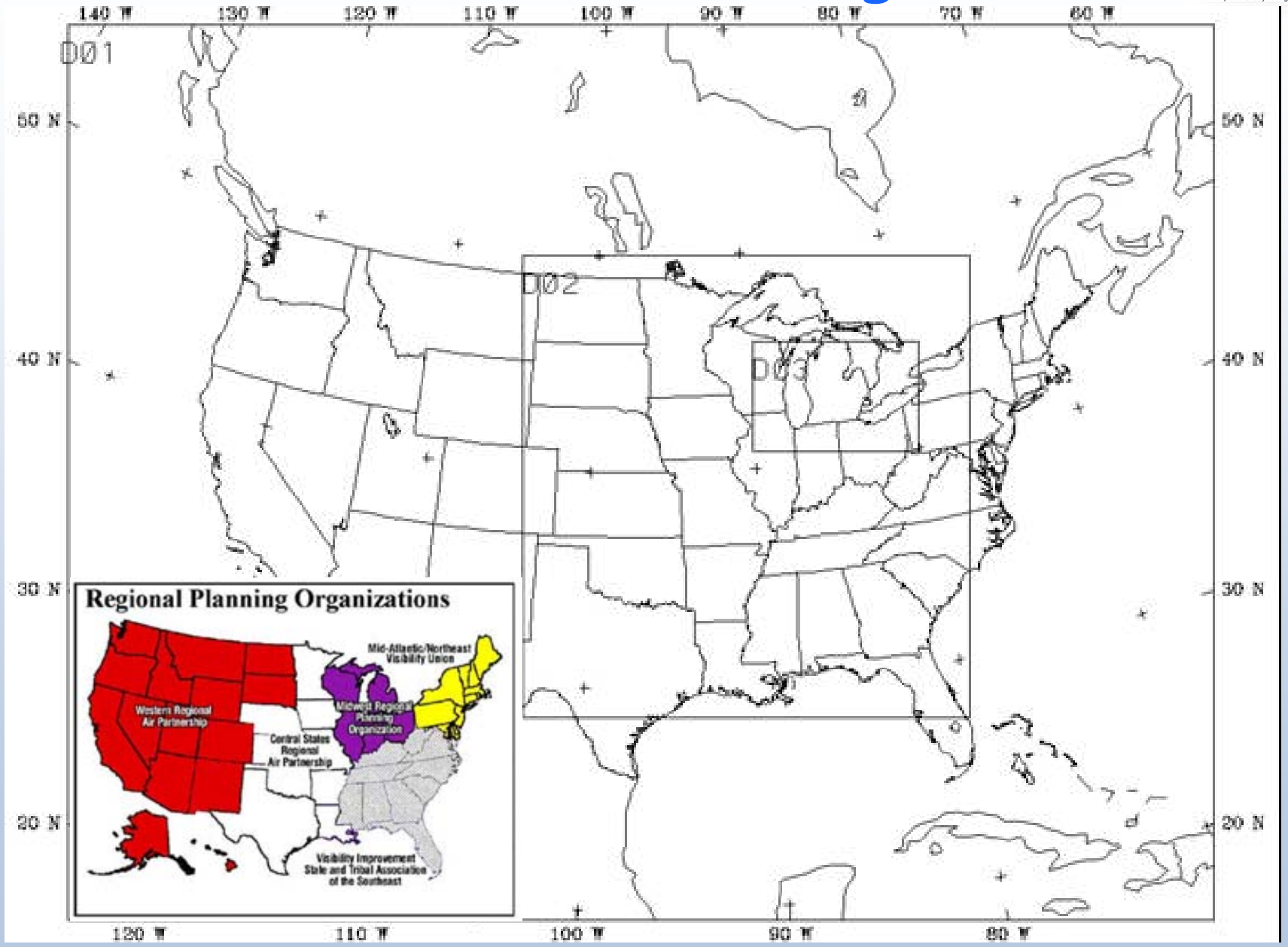
prepared by:
Dennis McNally
Alpine Geophysics, LLC

14 June 2007

MM5 Configuration

- Kain Fritsch II Cumulus Parameterization (36/12km only)
- Pleim-Xiu PBL and Land Surface Schemes
- Reisner 1 Mixed Phase Moisture Scheme
- RRTM Atmospheric Radiation Scheme
- 36/12 Run as continuous nest, 4km as nestdown

36/12/4 km MM5 Modeling Domain



MM5 Model Evaluation

- State variables evaluated
  - Mixing Ratio
  - Precipitation
  - Layer 1 Temperature
  - Wind speed and direction
- Evaluation performed on 36 km, 12 km, and 4 km grids
- 2005 MM5 simulation results compared with other regional model evaluations and with *ad hoc* met model performance goals in use by science community
- MRPO modelers (Kirk Baker) have conducted independent evaluation

McNally, D., and G. Schewe. 2006. "Evaluation of the 36/12/4 km MM5 for Calendar Year Focused on the Upper Midwest", prepared for the Midwest Ozone Group, prepared by Alpine Geophysics, LLC, Arvada, CO.

Monthly Temperature and Mixing Ratio

Table 4-1: Temperature Bias (K) For 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	-0.51	-0.26	-0.40	-0.31	-0.25	-1.10
WRAP 2002	-0.12	0.14	-0.15	-0.11	0.05	-0.49
VISTAS 2002	-0.05	0.14	0.00	0.05	0.24	-0.55
MRPO 2003	-0.15	0.11	-0.17	-0.10	0.18	-0.67
NMED 2005	0.52	0.86	0.15	0.58	0.75	0.13
NMED 2004	0.49	0.79	0.27	0.55	0.73	0.07
NMED 2003	0.27	0.54	0.21	0.28	0.65	-0.26
MOG 2005	0.38	0.75	0.05	0.49	0.61	-0.12

Table 4-2: Temperature Error (K) for 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	2.04	1.77	1.85	1.63	1.92	2.70
WRAP 2002	2.10	1.85	1.80	1.74	1.93	2.79
VISTAS 2002	2.02	1.76	1.80	1.72	1.84	2.67
MRPO 2003	2.17	1.94	1.86	1.92	1.98	2.82
NMED 2005	2.28	2.20	2.05	2.05	2.10	2.74
NMED 2004	2.26	2.13	1.99	2.01	2.11	2.75
NMED 2003	2.23	2.07	1.97	1.97	2.06	2.73
MOG 2005	2.26	2.16	2.05	2.03	2.07	2.74

Table 4-3: Mixing Ratio Bias (g/kg) for 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	-0.11	-0.24	-0.06	-0.22	0.06	-0.08
WRAP 2002	-0.09	-0.34	0.08	-0.11	0.20	-0.09
VISTAS 2002	0.01	-0.07	0.19	0.13	0.02	-0.04
MRPO 2003	0.22	0.11	0.30	0.29	0.49	0.05
NMED 2005	0.17	-0.02	0.54	0.24	0.47	-0.08
NMED 2004	0.07	-0.09	0.36	0.19	0.38	-0.20
NMED 2003	0.05	-0.18	0.35	0.17	0.35	-0.13
MOG 2005	0.29	0.11	0.59	0.30	0.67	0.03

Ad Hoc Met Model Performance Goals

- Temperature bias - +/- 0.5 K
- Temperature error - 2.0 K
- Mixing ratio bias - +/- 1.0 g/kg
- Mixing ratio error - 2.0 g/kg
- Wind Speed Index of Agreement – 0 = worst, 1 = best

Mixing Ratio and Index of Agreement

Table 4-4: Mixing Ratio Error (g/kg) for 36km Annual MM5 Simulations.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	1.02	1.09	0.80	0.85	1.13	1.04
WRAP 2002	1.03	1.17	0.82	0.93	1.16	0.94
VISTAS 2002	0.94	0.98	0.78	0.82	1.13	0.90
MRPO 2003	0.96	0.98	0.78	0.82	1.14	0.97
NMED 2005	1.12	1.20	0.96	0.97	1.32	1.03
NMED 2004	1.05	1.11	0.89	0.85	1.29	0.99
NMED 2003	1.03	1.09	0.86	0.85	1.22	1.00
MOG 2005	1.16	1.23	0.98	1.00	1.38	1.07

Table 4-5: Wind Index of Agreement for 36km Annual MM5 Simulation.

	ALL	CENRAP	MANE_VU	MW	VISTAS	WRAP
EPA 2001	0.88	0.85	0.69	0.75	0.77	0.86
WRAP 2002	0.93	0.92	0.81	0.84	0.84	0.92
VISTAS 2002	0.90	0.88	0.71	0.78	0.79	0.89
MRPO 2003	0.90	0.88	0.72	0.78	0.80	0.88
NMED 2005	0.87	0.84	0.71	0.73	0.75	0.86
NMED 2004	0.90	0.88	0.76	0.77	0.79	0.88
NMED 2003	0.90	0.88	0.76	0.77	0.79	0.88
MOG 2005	0.87	0.84	0.71	0.73	0.75	0.86

Ad Hoc Met Model Performance Goals

- Temperature bias - +/- 0.5 K
- Temperature error - 2.0 K
- Mixing ratio bias - +/- 1.0 g/kg
- Mixing ratio error - 2.0 g/kg
- Wind Speed Index of Agreement – 0 = worst, 1 = best

Monthly Mixing Ratio Performance
4 km MRPO Grid

Bias, gm/Kg

Region	Jun '05	Jul '05	Aug '05	Sep '05	Mean
ALL	0.81	0.23	0.07	0.56	0.42
IL	0.90	0.35	0.05	0.47	0.44
IN	0.69	0.12	-0.42	0.75	0.28
MI	0.83	0.18	0.05	0.84	0.47
MRPO4KM	0.80	0.23	0.08	0.53	0.41
OH	0.71	0.14	0.08	0.20	0.28
WI	0.80	0.23	0.04	0.30	0.34

Error, gm/Kg

Region	Jun '05	Jul '05	Aug '05	Sep '05	Mean
ALL	1.50	1.45	1.32	1.53	1.45
IL	1.54	1.55	1.35	1.59	1.51
IN	1.47	1.43	1.45	1.61	1.49
MI	1.51	1.37	1.30	1.65	1.46
MRPO4KM	1.49	1.43	1.30	1.51	1.43
OH	1.44	1.48	1.32	1.38	1.41
WI	1.51	1.46	1.20	1.42	1.40

Monthly Temperature Performance
4 km MRPO Grid

Bias, deg K

Region	Jun '05	Jul '05	Aug '05	Sep '05	Mean
ALL	0.67	0.65	0.64	0.32	0.57
IL	1.12	0.99	1.17	0.65	0.98
IN	0.57	0.37	0.55	0.11	0.40
MI	0.50	0.59	0.50	0.14	0.43
MRPO4KM	0.63	0.60	0.58	0.24	0.51
OH	0.86	0.75	0.91	0.70	0.81
WI	0.42	0.45	0.32	0.14	0.33

Error, deg K

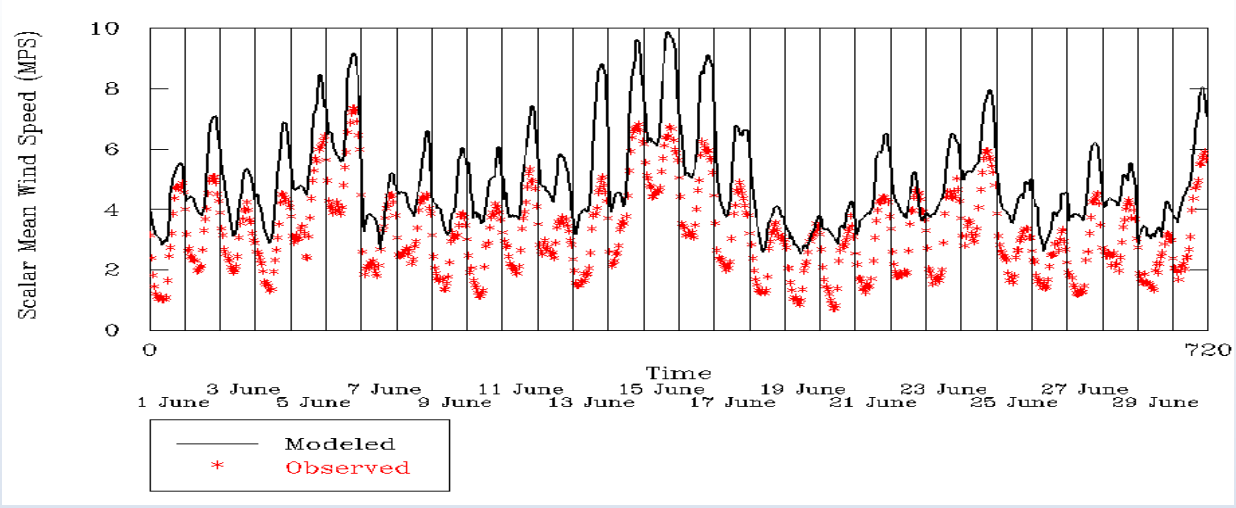
Region	Jun '05	Jul '05	Aug '05	Sep '05	Mean
ALL	2.22	2.25	2.23	2.63	2.33
IL	2.38	2.31	2.34	2.66	2.42
IN	2.14	2.19	2.15	2.78	2.32
MI	2.28	2.40	2.29	2.85	2.45
MRPO4KM	2.20	2.23	2.19	2.58	2.30
OH	2.20	2.08	2.11	2.43	2.20
WI	2.06	2.15	2.14	2.46	2.20

Monthly Wind Speed Performance
4 km MRPO Grid

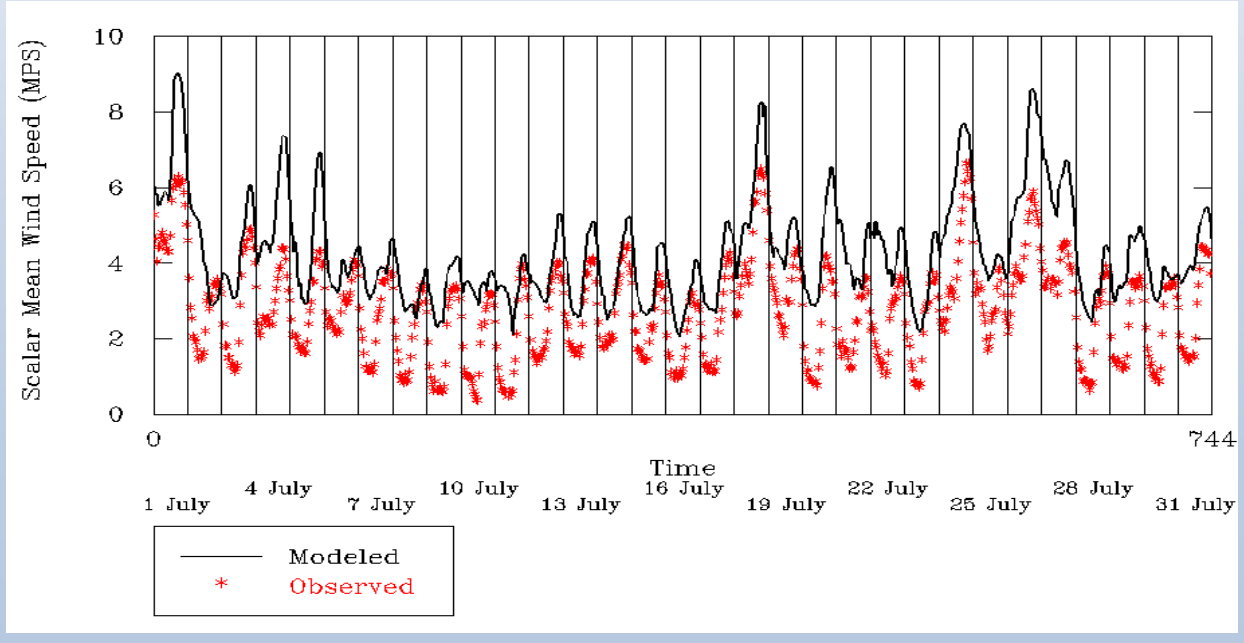
Index of Agreement

Region	Jun '05	Jul '05	Aug '05	Sep '05	Mean
ALL	0.65	0.68	0.66	0.66	0.66
IL	0.51	0.52	0.54	0.54	0.53
IN	0.51	0.52	0.53	0.50	0.51
MI	0.59	0.57	0.57	0.58	0.58
MRPO4KM	0.68	0.66	0.66	0.66	0.67
OH	0.57	0.59	0.60	0.57	0.58
WI	0.56	0.56	0.55	0.56	0.56

Wind Speed Performance
4 km MRPO Grid

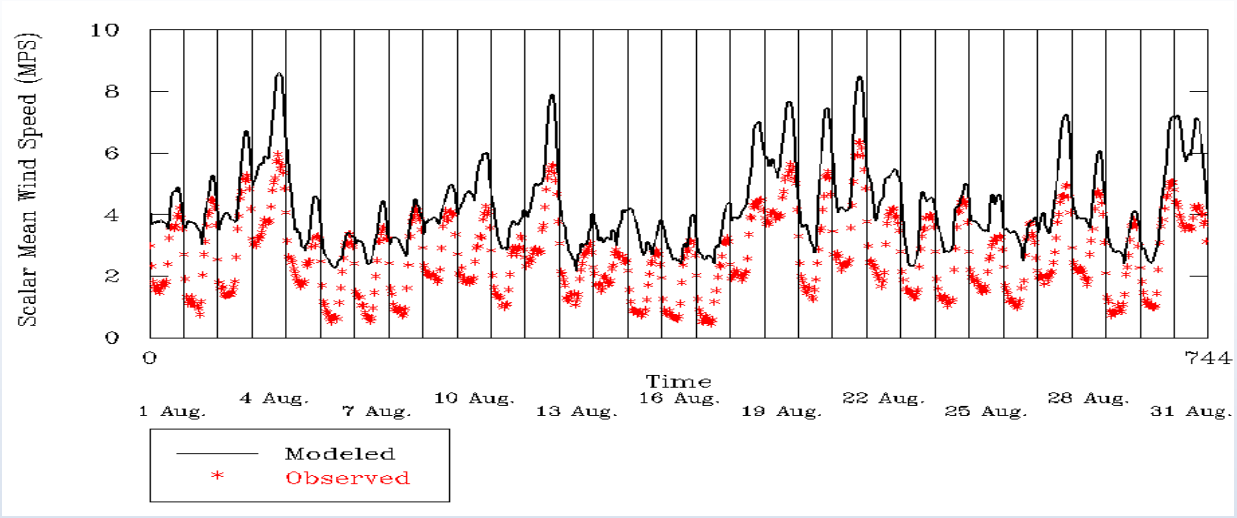


June

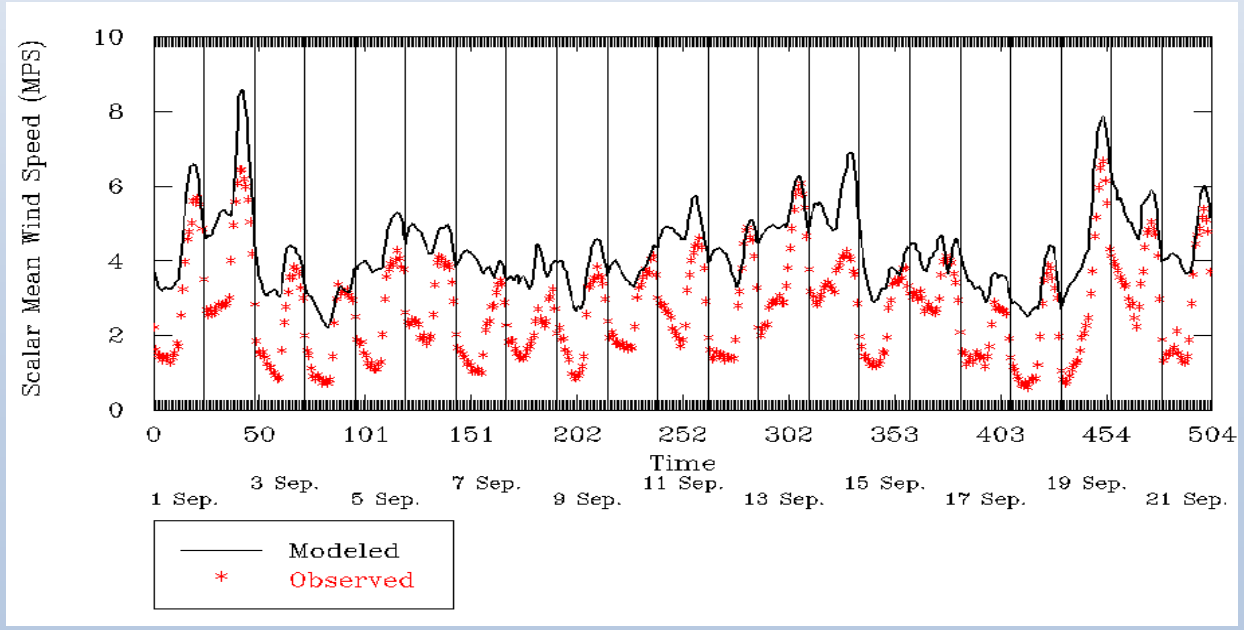


July

Wind Speed Performance
4 km MRPO Grid

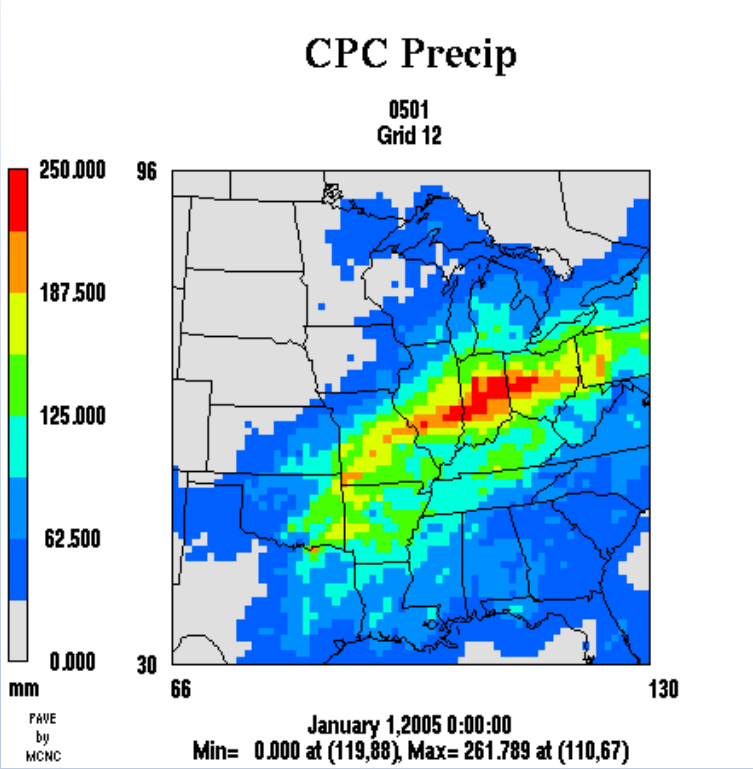


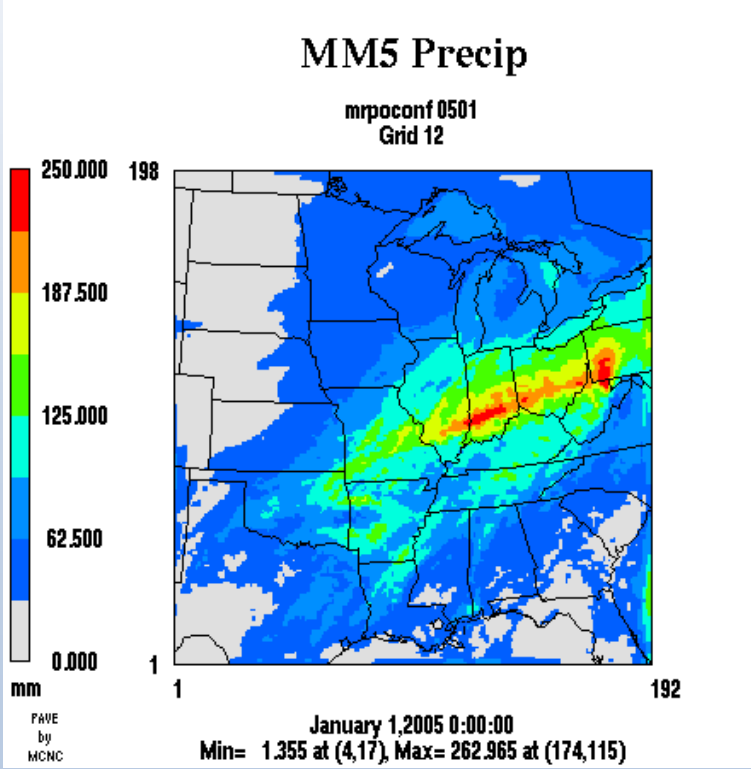
August



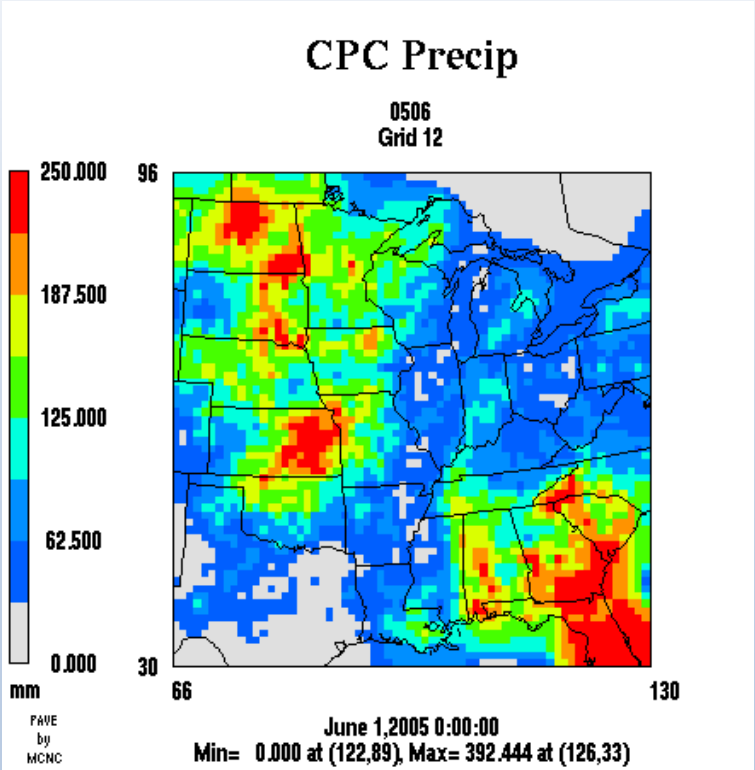
September

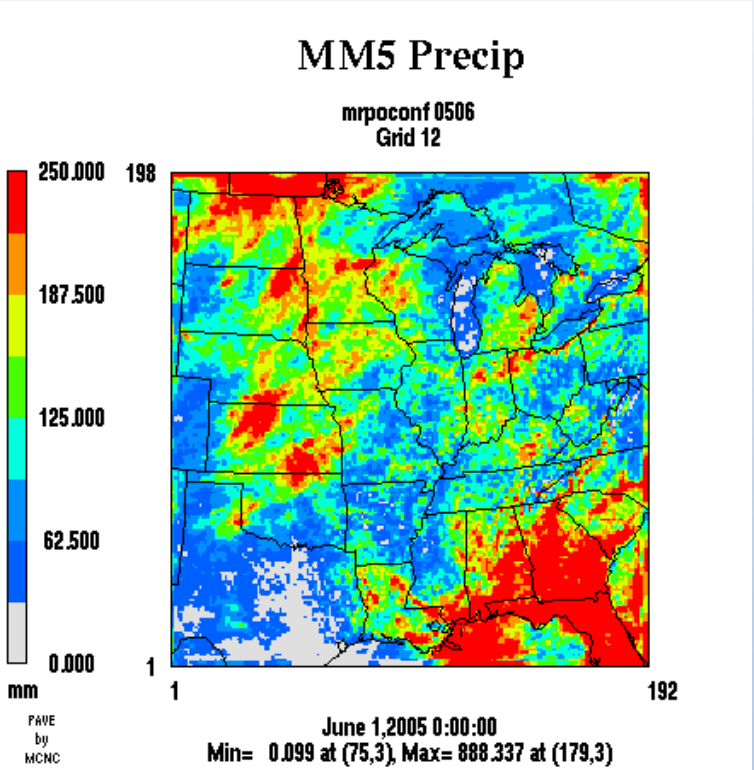
12km Monthly Precipitation



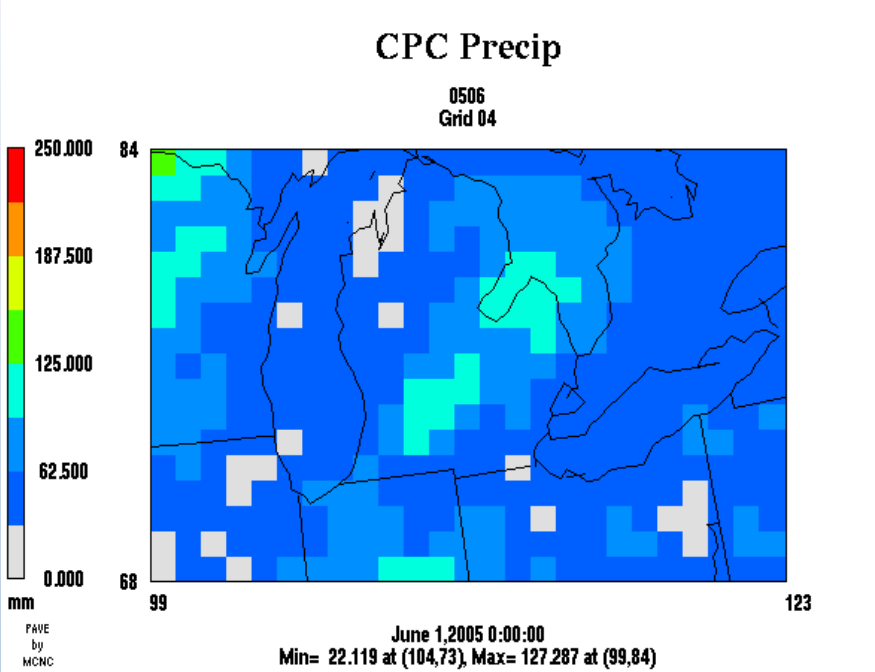


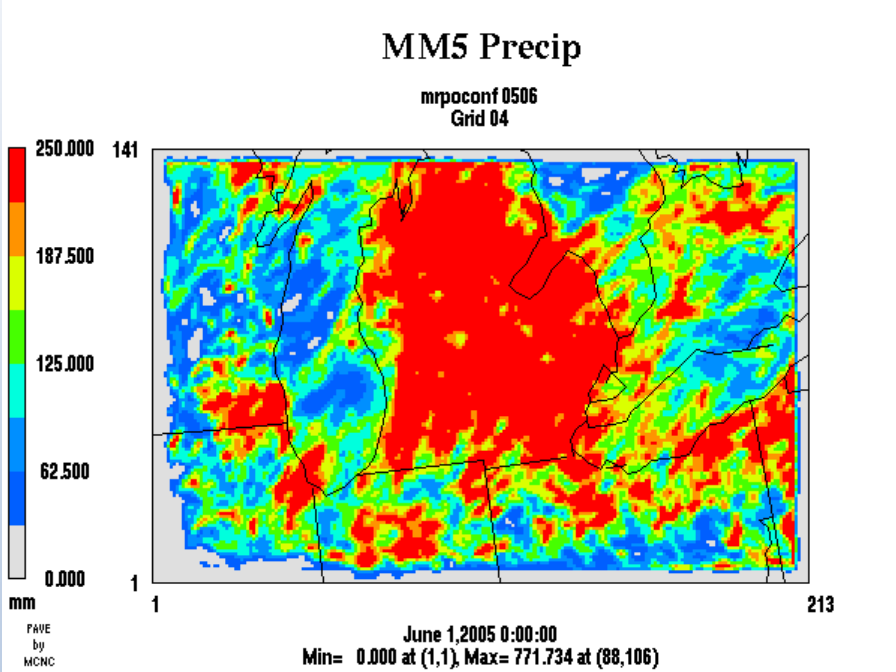
12km Monthly Precipitation





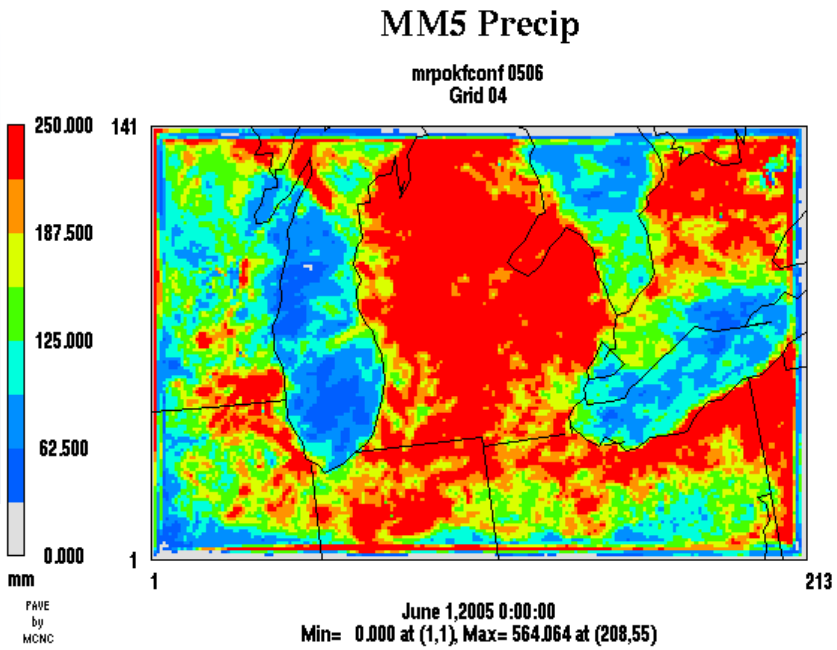
4km Monthly Precipitation

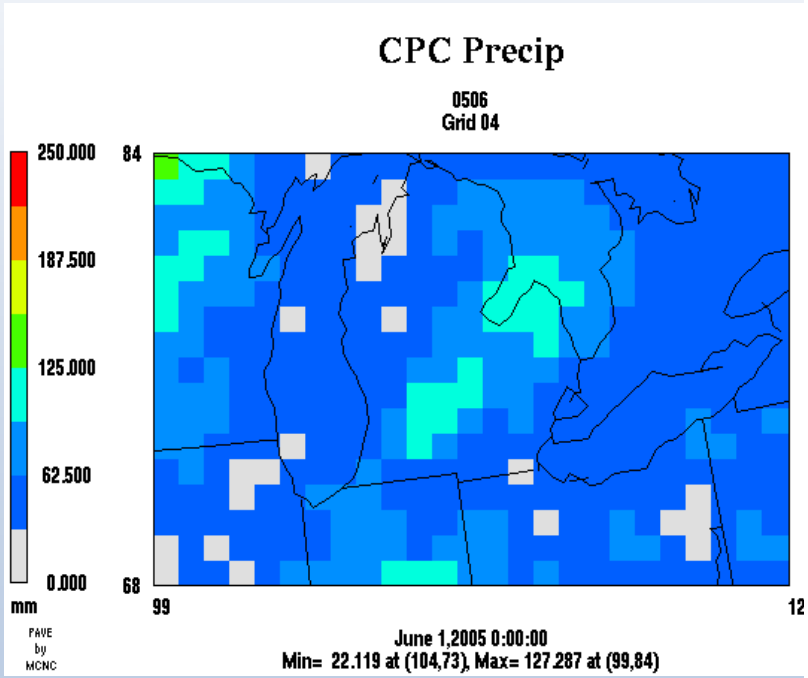


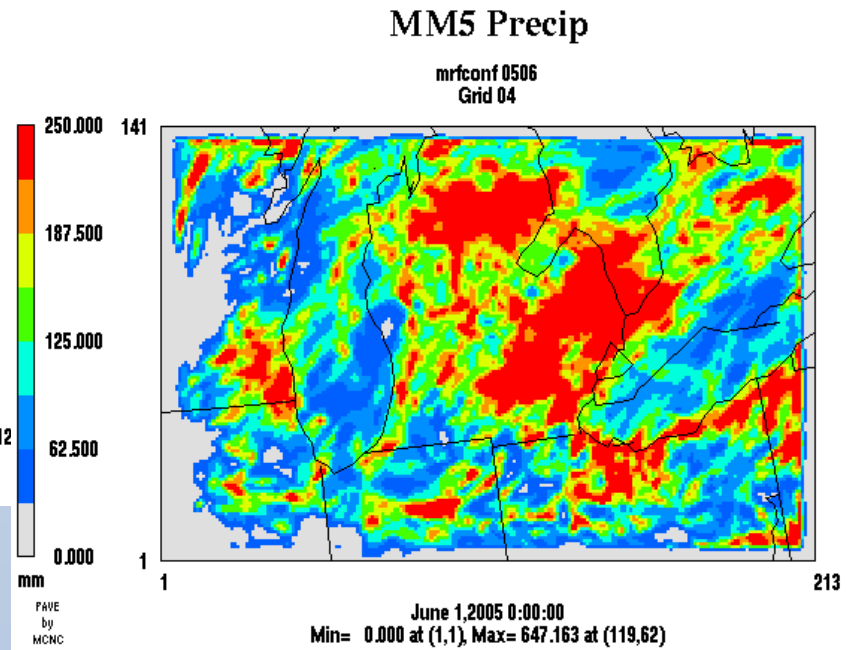


4km Monthly Precipitation

- Precipitation Overestimation on 4km Grid
  - Seen in other applications (Four Corners, Denver, Baton Rouge, Birmingham)
  - MM5 generally estimating timing and coverage of precip. events, but overestimating rates
- Sensitivity Tests to Try to Correct
  - KF2 – Turned on KF2 Cumulus Parameterization at 4km
  - MRF –
    - MRF PBL instead of Pleim/Chang
    - Slab soil instead of PX LSM







MRF Somewhat Better:

Base configuration used in AQ

MM5 Model Evaluation Summary

- Operational evaluation performed on 36/12/4 km grids
- 2005 MM5 simulation performance at 36/12 km scales quite consistent with other 8-hr ozone, $PM_{2.5}$, regional haze modeling studies (e.g., EPA, MRPO, VISTAS, WRAP, NMED)
- On 4 km MRPO grid
  - Mixing ratio bias well within ad hoc goal of $\pm$ 1.0 g/Kg
  - Mixing ratio error well within ad hoc goal of 2.0 g/Kg
  - Temperature bias generally within range of goal of $\pm$ 0.5 deg K
  - Temperature error typically slightly outside goal of 2 deg K
  - Model does a good job of reproducing hourly variation in surface wind speeds but tends to overestimate peak afternoon speed by as much as 1-3 mps
- 2005 MM5 simulation clearly acceptable for regulatory modeling purposes

References

McNally, D., and G. Schewe. 2006. "Evaluation of the 36/12/4 km MM5 for Calendar Year Focused on the Upper Midwest", prepared for the Midwest Ozone Group, prepared by Alpine Geophysics, LLC, Arvada, CO.